

Digital 3-D Headforms Representative of the Current Chinese Workers

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Objective

The objective of this study was to create digital 3-D headforms that are representative of the current Chinese workforce

Introduction

- More than 20 headform tests are used in respiratory protection and eye and face protection standards being developed by the International Organization for Standardization (ISO)
- China has the largest population in the world and millions of Chinese workers rely on respirators and other personal protective equipment to reduce the risk of injury and occupational diseases
- The current Chinese standard series of headforms is based on data that is more than 40 years old
- In 2006, Tongji Medical College conducted an anthropometric survey of 3000 Chinese civilian workers (350 scanned with a Cyberware 3-D Rapid Digitizer)
- Respirator fit test panels for Chinese workers were developed which provide an objective tool for selecting human test subjects based upon their facial characteristics for use in research, product development, testing and certification^{1,2}
- Using a methodology developed by the National Institute for Occupational Safety and Health (NIOSH), scans were used to develop a series of five digital headforms³
- Lessons learned applying this methodology on other anthropometric databases can be used to improve headforms for US workers and to better understand the differences in face sizes and shapes between US workers and those in other countries

Methods

- Ten facial dimensions relevant to respirator fit were chosen for defining a principal component analysis (PCA) model which divided the user population into five face-size categories (Figure 1)
- Mean facial dimensions were computed to target the ideal facial dimensions for each size category
- Five scans were chosen from each size category to be used in the construction process
- Selected scans were then averaged together, with Polyworks® 10.1.6 (InnovMETRIC, Quebec QC Canada), to construct a representative headform for each size category

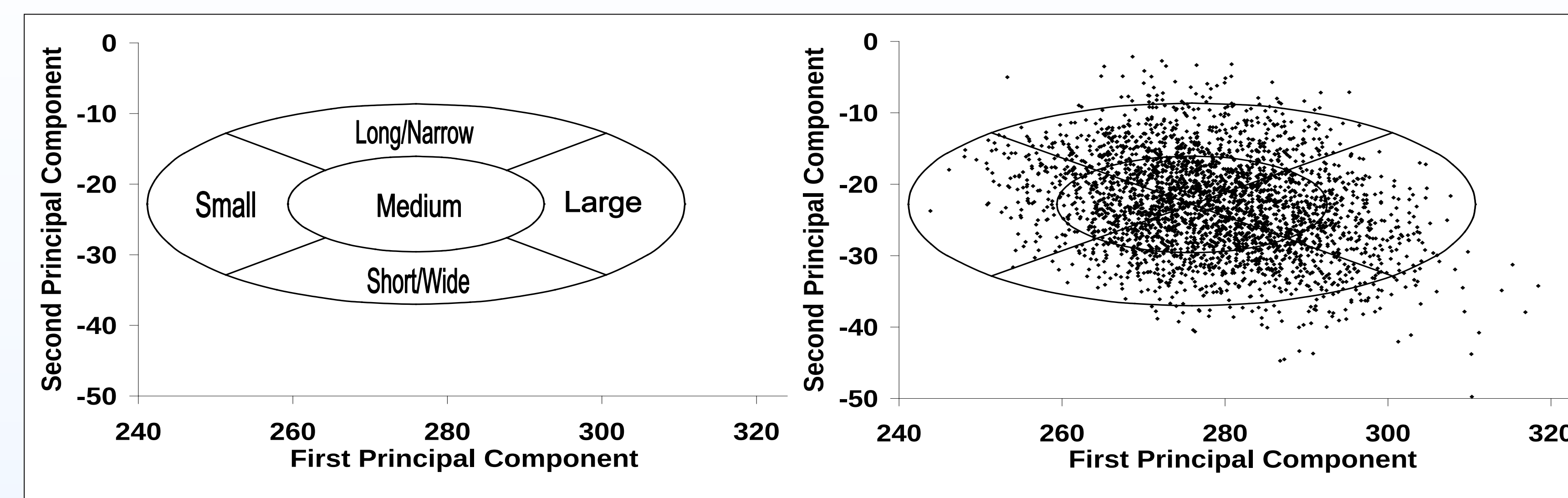


Figure 1. The Chinese PCA respirator fit test panel with size categories (left) and the subject distribution of PC1 and PC2 calculations based on dimensions collected manually for all surveyed subjects (right).

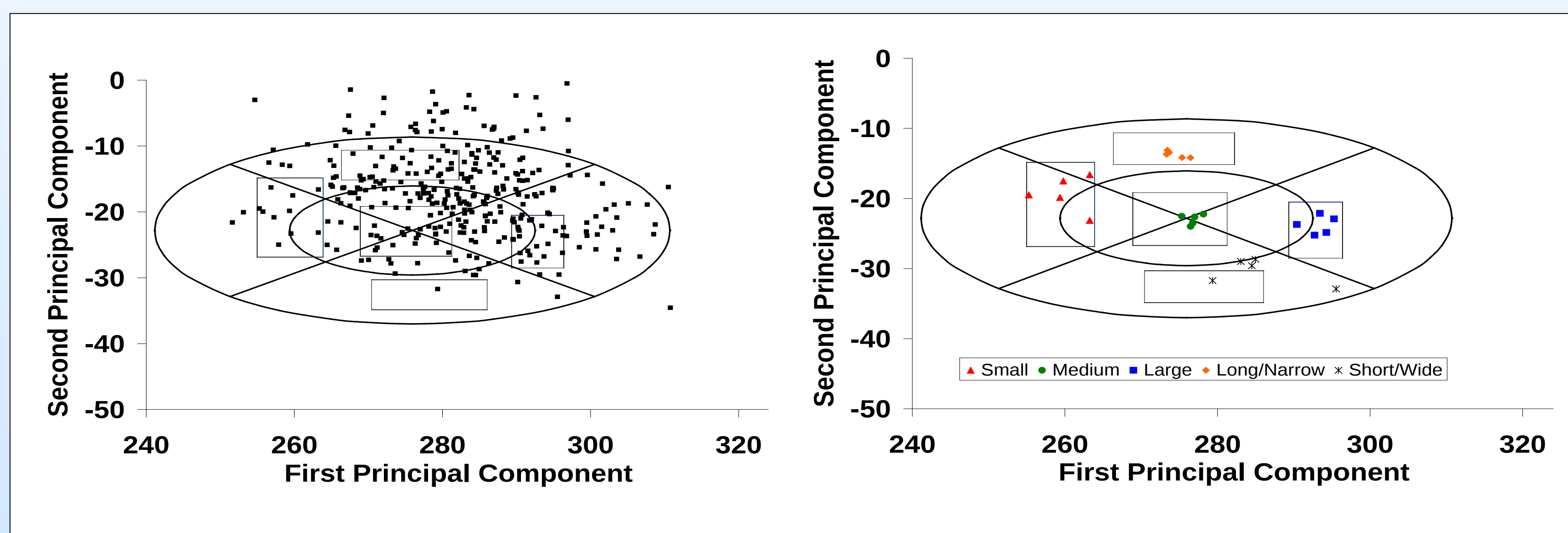


Figure 2. The distribution of PC1 and PC2 calculations of scanned subjects based on dimensions measured using Polyworks 10.1.6 (left). The head breadth dimension was corrected using a regression equation to account for larger width values due to the presence of hair and a wig cap. The five subjects chosen for the headform average are shown on the right.



Figure 3. The five scans chosen for the development of the medium headform.

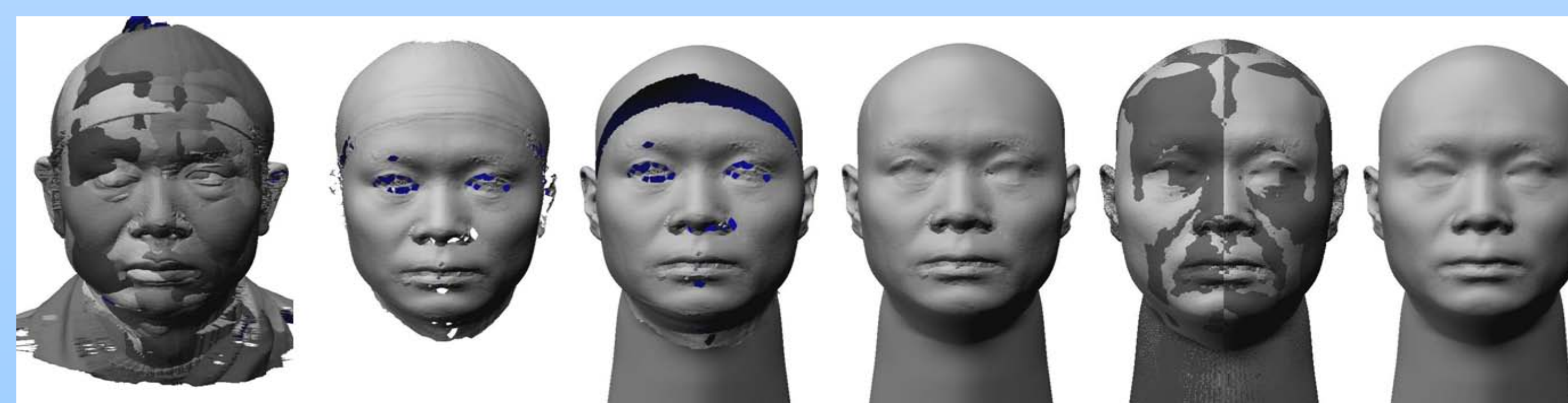


Figure 4. The stages of the averaging process from left to right: align the five scans using the Frankfort plane, take an average, place the average on a medium neck with ears and a scalp, fill in all holes, duplicate and mirror the filled in headform and take another average, complete the headform by making it watertight.

Results & Discussion

- Five digital 3-D headforms were developed: small, medium, large, long/narrow and short/wide
- All dimensions are within 3 mm of the computed means for the sample population in each size category except for short/wide
- The scanned sample population only had one individual that landed within the optimal size location for short/wide faces

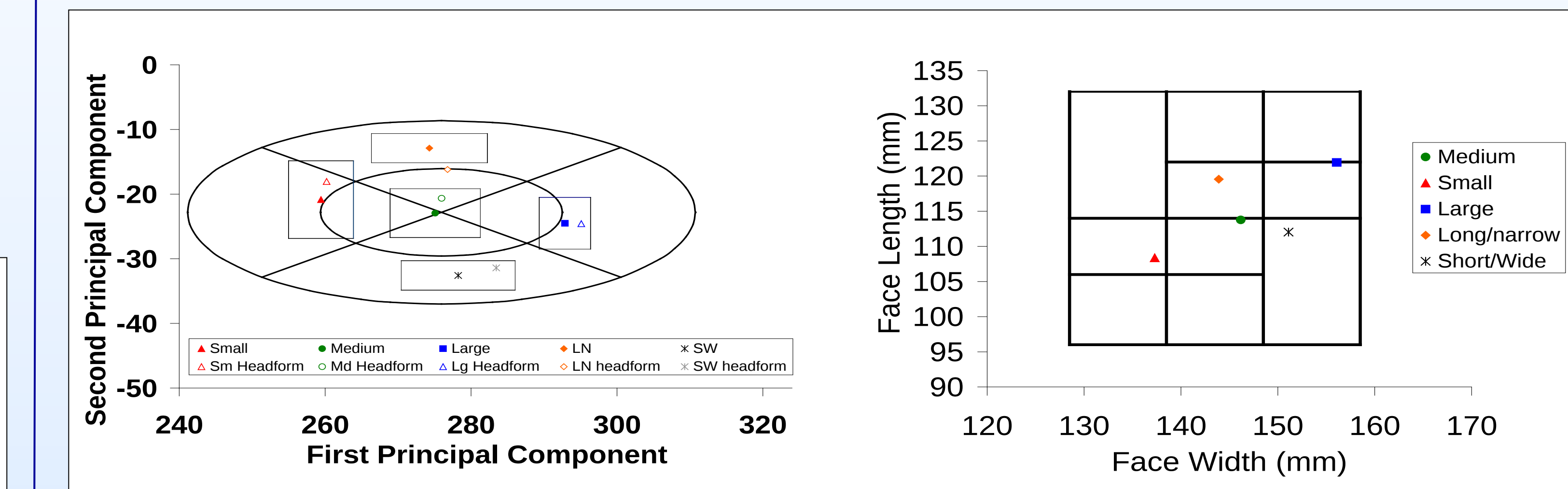


Figure 5. The distribution of the new Chinese headforms in the Chinese PCA panel compared with the mean of each face size category calculated from the manual measurements of 3000 subjects (left), and the distribution within the Chinese bivariate panel (right).

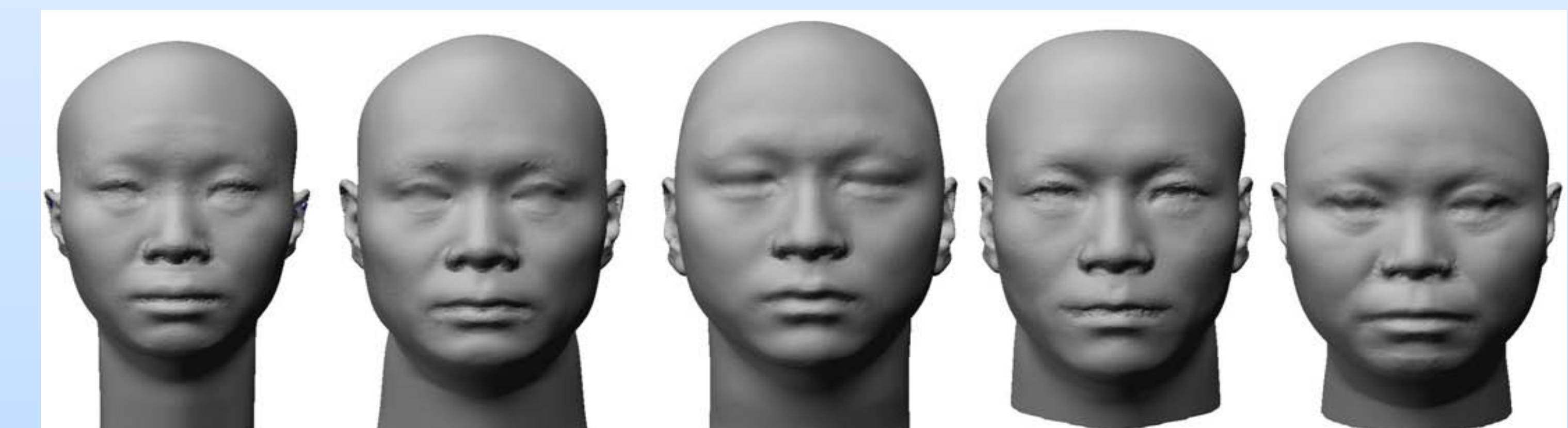


Figure 6. The five Chinese digital headforms from left to right: small, medium, large, long/narrow and short/wide.

Conclusions

- New Chinese headforms represent the facial size and shape distribution of current Chinese workers and may be useful for respirator research, incorporation into Chinese and international respirator standards, and respirator product development
- Future considerations include validating these headforms and collecting scalp and tissue depth data on facial features

References

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